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Integrating service discovery technologies in OSGi platform ☆

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ABSTRACT

This paper describes the service discovery and interaction for home network devices using heterogeneous standards and protocols. OSGi was proposed to allow several kinds of services coming from different providers to be loaded and run on a gateway. We present a residential gateway based on the OSGi architecture for a smart home network. We combine the SLP SA/DA, the UPnP control point and the SIP UA into the gateway to achieve automated device discovery, registry, and management. Application examples are introduced and the implementation results show that our gateway can provide automatic heterogeneous service or device discovery, registry, and management.

1. Introduction

In the past decade, communication technology has undergone a tremendous change. Due to the fast and prosperous advancement of online communication technologies, network service can greatly facilitate human daily life. With the rapid expansion of the Internet and the availability of communication technologies, networked home appliances are proliferating at an accelerated pace. For example, more commonplace home appliances are being interconnected with the Internet. Various network services and multimedia services are available throughout the network. Through the network, users can remote access and control over home electrical appliances from office.

With the number of networked devices or services within the home, an efficient interconnection protocol and management platform has become crucial research work. For a service consumer, it is difficult to have a complete overview of these services and their availability. These devices produced by different manufacturers have different communication protocols. The dynamics of network devices and services make this process even more complex. Finding the available network service and devices becomes an important issue for constructing a home network. The service discovery mechanism was proposed to support the user in finding available network services or devices.

Therefore, the service consumer can find or access network devices or services through the network that are capable of interacting with each other using the service discovery mechanism. Numerous protocols, middleware, and standards, such as JXTA [1], UPnP [2], SLP [3,4], and SIP [5], have proposed for interconnection or discovery with these home networked devices. A lot of researches implement a residential gateway based on the OSGi plan to interconnect or discover heterogeneous network devices or services. OSGi (Open Service Gateway Initiative) [6] defines open specifications and standards for the delivery of managed services to networked environments. It is an industry plan for a standard way to connect network devices such as home appliances or network services. The OSGi framework allows several kinds of services coming from different providers to be loaded and run on a service gateway. The OSGi platform can serve as the central coordinating point for managing the home network, spanning multiple heterogeneous communication technologies.

Although, the OSGi platform can serve as the central coordinating point for spanning multiple heterogeneous communication technologies, the devices still cannot discover the UPnP services and devices using SLP or JXTA. It is because that these service discovery standards and protocols are mostly proprietary and do not operate easily with other networks. This paper proposes and implements a way to bind several home network protocols, making the devices or services of one network discoverable to others. We present a residential gateway based on the OSGi architecture for a smart home network. To achieve automated heterogeneous devices discovery, registry and management, the SLP (Service Location Protocol) SA/DA component, the UPnP (Universal Plug and Play) control point and the SIP (Session Initiation Protocol) UA, will be integrated into the OSGi platform. We also integrate the SLP UA, UPnP control interface into the SIP UA. Based on our proposed architecture, the user can easily discover and access the UPnP devices and service using the SLP UA and SIP UA.

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The remainder of this paper is organized as follows. The related literatures on session discovery are discussed in Section 2. Section 3 proposes the OSGi-based control architecture, as well as how the SLP SA/DA, the UPnP control point and the SIP UA can be combined into the gateway. The implementation architecture and the implementation results from our architecture are described in Section 4. Finally, we draw our conclusions and some future works in Section 5.

2. Related works

The aim of ubiquitous computing is to integrate computer devices and network services into daily human life. The user can access any telecom or datacom service as voice, video or data, anywhere at any time with any devices. Therefore, this is a desirable service if a user can change the communication device adaptively, according to his surrounding environment, during a communication session. In [7], Schulzrinne et al. proposed an intelligence system, that provides a ubiquitous computing environment in the home network. To provide ubiquitous computing a lot of techniques and services should be integrated into the intelligence system. The location sensing service is the key component used to locate the user's position. Based on the correct position information, the intelligence system can provide available services or devices to the user. The Bluetooth technique, GPS, and sensor network can be used in the location sensing services. The resource discovery and control servers provide the user with available service or devices for controlling these services and devices. The SLP and SIP were introduced to provide service discovery and control. The access control system allows the user to remote control home appliances.

Based on the architecture proposed in [7], Shacham et al. proposed the detail implementation in [8]. In [8], the SLP was used to search for service, with SIP used to control the network devices. To provide session mobility over multiple devices, the “Virtual Device” concept or a Multi-Device System (MDS) was introduced. Two different modes were involved in their system. In the Mobile Node Control (MNC) mode, the user agent transfers and retrieves the session using a Third Party Call Control (3PCC) mechanism. Session Handoff (SH) mode uses REFER method, which is a SIP extension method defined in RFC 3515, to establish a SIP session with each device. To efficiently manage the session over multiple devices, the Multi-Device System Manager (MDSM) was introduced.

We also proposed a mechanism, referred to as “Split a SIP session over multiple devices (SSIP)” [9], to provide split session service. Some improvements were involved in our mechanism to obtain the ability to split a session. The extension header “Mobility” was introduced to improve the REFER method and make it transparent to the remote party. The “Association” record was used to terminate all split sessions separately when a session was split over multiple devices. Moreover, in order to facilitate transferring, splitting and retrieving a session over multiple devices, we proposed a complete mechanism, referred to as “Session Integration Service” [10]. In order to provide facility session mobility, three new agents, session manager, session user, and free node were introduced in our mechanism. The session manager transformation (SMT) procedure and the session manager acquirement (SMA) procedure were introduced to provide much more flexibility in session mobility.

To integrate the service discovery service in the home network, Dobrev et al. introduced the OSGi platform to solve the problem in [11]. Based on the Bridge bundle, the UPnP services and Jini services were working as the services in the OSGi platform. Thus, the OSGi services and the UPnP devices can be interconnected. In [12,13], the authors proposed a solution that uses the SIP and the Bridge bundle of the OSGi platform to interconnect and access heterogeneous network devices or services. [14] proposed a solution to provide service discovery by SIP. In [15], the OSGi platform was improved to support the ALL-IPv6 environments. In [16], Wu et al. proposed a P2P interaction model with the OSGi platforms to provide the ability to interconnect networks with different technologies. In [17], Ai et al. improve the OSGi platform to support automotive telematics. However, the service discovery mechanism was not considered in their architecture.

3. System architecture

3.1. Related protocols

3.1.1. Service Location Protocol

The Service Location Protocol (SLP), defined by IETF, is an Internet standard network protocol that supports the user in finding the existence, location and configuration of available network services. This protocol enables service registration and simplifies any subsequent search for services. SLP is used by devices to announce services or discover services on an unmanaged network.

Each service can be located using the Uniform Resources Locators (URLs). The URL can have an IP address or the domain name, and the service type. The service types can be classified into a particular service type or abstract service type. The well known network services, such as http, ftp, and so on, are belonged to a particular service type. The abstract service type is associated with a variety of different service agents, such as a printer, webcam and so on.

To efficiently manage and discover services three network components are involved in the SLP architecture. They are Service Agents (SAs), Directory Agents (DAs) and User Agents (UAs).

The SLP SA is a device that provides one or more services in a network. The SLP SA can advertise services to the SLP DA or provide service information to the SLP UA when the desired service matched.

The SLP DA is a process that manages the services registered from the SLP SAs, or applications stored in DA's local database. The SLP DA can provide service information when the SLP UA sends its discovery request.

The SLP UA is a software entity used to search for network services. Without any network service or network host names, the users can find the available services using only a description of the desired service. The SLP UA sends a request with the description to the SLP SA or the SLP DA, and the SLP SA or the SLP DA will then return the response with the URL for the desired service.

SLP can support the network scale from small, unmanaged networks to large enterprise networks. All the network devices and services can be grouped into several scopes. Each device or service should be in one or more scopes. In SLP, the scope is a set of network devices or services. A scope can be described as a simple string and denoted as the domain name in a campus network or the department name in an enterprise network. The SLP UA can only search the network devices or services from its scope. SLP allows the administrators of a scope to organize users, network devices and servers into administrative groups.

In SLP, the SLP UA can directly send search requests to the SLP SA. In this case, the SLP UA sends a request by multicasting. When the SLP SA receives a request that it can service, the SLP SA will reply with a unicast message containing the service's location to the SLP UA. This kind of approach is suitable for small, unmanaged networks.

In larger networks, as the number of SLP SAs grows, it becomes necessary to partition these devices into several scopes. One or more SLP DAs are used for each scope. The SLP SAs first issue a register message containing all of the services that they provide to the SLP DAs. The SLP DAs will then reply with acknowledgements to the SLP SAs. The advertisements must be refreshed by the SLP SAs periodically before the timer expires. When the user wants to find a desired service, the SLP UA will send a unicast request with the query service to the SLP DA. The SLP DA will reply with a unicast message containing the service's location to the SLP UA.